Money illusion, financial literacy and numeracy: experimental evidence

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Abstract

Money illusion is usually defined as the inability of individuals to take into account evolution of price in their nominal calculation. Individuals are no longer rational as defined by economic theory. Empirical evidence shows that money illusion matters in financial decisions particularly those made by households. In this article we analyse money illusion at the individual level and study its relation with numeracy and financial literacy. In order to do so we propose an original and precise measure via an experimental task and analyse the effects of financial literacy and numeracy via usual measures. This task consists in a series of choices between a pair of simple bonds which returns are influenced by inflation (deflation) rates. It provides a fine measure of money illusion which is correlated with usual measures of it (questionnaires). Moreover we show that money illusion depends on the context of the choices and on the participants' skills. Individuals with financial knowledge, and to a lesser extent numeracy skills, are less sensitive to money illusion than others.

JEL Classification : C9 ; D1 ; E2 ; G4.

Keywords: Money illusion; Behavioural finance; Financial Literacy; Numeracy.

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INTRODUCTION

Money illusion is a complex phenomenon that has long been recognized. Fisher first defined it as the "*failure to perceive that the dollar, or any other unit of money, expands or shrinks in value"* (1928, p. 4) or "*the tendency of people to think of money in nominal, rather than real terms"* (1928, p.4). More generally, Keynes (1936) considered that money illusion occurs when "*individuals do not accurately take inflation into account*". In this broad sense, money illusion was resumed by Patinkin's (1956) as *"any deviation from real decision-making*" and constitutes a violation of what Leontief (1936) called the "*homogeneity postulate*" extended to real balances. Accordingly, rational agents make their decisions in the absence of money illusion defined as the zero-degree homogeneity of net demand functions in all money prices and the money value of initial wealth. The absence of money illusion is then postulated in standard models by assuming perfect rationality and is required to ensure the neutrality of money.

The existence, nature and extent of money illusion are then empirical questions. Recent evidence supports the relevance of money illusion in a variety of contexts (housing, financial markets, etc). This evidence consists of results of surveys, empirical studies as well as natural and laboratory experiments or even neuroeconomic experiments (Shafir, Diamond and Tversky (1997); Modigliani and Cohn (1979); Cohen, Polk and Vuolteenaho (2005); Kooreman, Faber and Hofmans (2004); Fehr and Tyran (2001, 2007); Noussair, Richter and Tyran (2007); Weber et al. (2009)).

Besides money illusion, financial choices may be affected by other biases, as for instance myopic choices. Irrationality may also come from cognitive limitations around numeracy and financial literacy, which may strongly affect financial decisions such as retirement plans.

Direct evidence linking irrationality and cognitive limitations is however scarce, especially for money illusion. Additionally, the empirical literature lacks a precise measure of money illusion at the individual level.

Consequently, the aim of the paper is twofold: first, to propose a simple task to measure money illusion at the individual level; and second, to emphasize the relationships between money illusion and cognitive abilities in the context of financial choices. To establish a link, we need to have individual measures of money illusion and cognitive abilities such that numeracy and financial literacy. For that purpose we propose a simple and unbiased financial choice task to measure money illusion while we identify cognitive abilities with usual metrics.

The rest of this paper is organized as follows. In section 1, we review the related literature and define our hypotheses. In section 2, we present the methodology of the experiment. In section 3, we analyze the results. Finally, the results are briefly discussed in the conclusion. Questionnaires used and experimental materials are given in the Appendices.

1. RELATED LITERATURE AND HYPOTHESES

Money illusion commonly defined as agents' tendency to think in nominal rather than real terms is usually attributed to intuitive decision making based on more accessible information since real-life economic situation are dominantly expressed in nominal terms (Shafir, Diamond and Tversky, 1997; Fehr and Tyran, 2001, Akerlof and Shiller 2010). Shafir, Diamond and Tversky (1997) provide individual level questionnaire evidence on money illusion by submitting hypothetical scenarios to lay judgments of increase or decrease of wealth or incomes in inflationary and deflationary contexts. They report serious focus on nominal values or changes which are analyzed as a framing effect reflecting agents' preference for the nominal framework given its facility and salience. However, the authors observe that agents may use a mix of both framing and that the favored cognitive framework may vary depending on the context since agents are, for instance, more likely to use the real framework in case of hyperinflation.

De facto, when inflation is high its effects are easy to identify and agents are willing to be protected against it. On the contrary when inflation is low it is more difficult to appreciate the erosion in the real value of money, especially over long periods of time. Besides, money illusion can be interpreted as a form of *bounded rationality* (Simon, 1978) especially in financial markets: investors are more subject to money illusion in their decisions making when the cost of negligence is small (low inflation).

Consequently, Bodie and Crane (1997) argue that this phenomenon can lead to an inadequate pension structure. They report that pensioners, in western countries where inflation rate is usually quite low, failed to anticipate the loss in the purchasing power of their pension's overs their remaining of life. Plus, this phenomena and issue increasing with life expectancy.

We can relate this framing to the notion of mental accounting (Thaler, 1985). Mental accounting refers to the phenomenon whereby people keep track of gains and losses in different mental accounts. Consequently, people do not evaluate via different mental accounts financial choices frame in inflation or in deflation situations.

Moreover, cognitive dissonance and the self-attribution bias might be another reason why individuals are sensitive to money illusion. People have a tendency to attribute increasing of their nominal income to their own achievements rather than to higher inflation rate.

Finally, the framing effect states that alternatives representations (framing) of the same decision problem can lead to substantially different behavior (Tversky and Kahneman, 1981). According to Shafir, Diamond and Tversky (1997) agent's preferences depend on whether the problem is phrased in real or in nominal terms. Accordingly, the assessment of wealth is influenced by both the nominal value and the reference point, which are jointly used to determine gains and losses. Here in this study we will focus only of the assessment of nominal value according to different set of framing.

As we point out money illusion has significant consequences on financial choices and portfolio composition. An important area of research has focused on the link between money illusion and inflation-indexed bonds. Precisely, Fisher (1928) argued that the prevalence of money illusion in financial choices justifies the need for indexed-bonds. The theory of indexation started with Jevons (1875), who wrote in favor of indexed bonds and other indexed contracts According to Fisher, households and investors benefit from the introduction of inflation-indexed bonds due to the prevalence of money illusion. Indeed, inflation-indexed bonds provide an asset against the risk of inflation and they enable to increase portfolio diversification.

Yet, historically the experience with indexed bonds was not as successful as it could have been expected. According to Shiller (2005), the world's first known inflation-indexed bonds were issued by the state of Massachusetts during the American Revolution (1780). Since then, however, such experience was not repeated for a long time.[1] Following Finland in 1945, several countries introduced indexed-bonds (UK, 1975; USA 1997; France 1998…) but they still represent a small share of their national debt. Subsequent research sought to establish an empirical link between money illusion and indexed bonds and clarify the reasons why the latter have not been more widely adopted. For instance, Shiller (1997) finds that although most of the respondents to his questionnaire in the US and in Turkey were able to deal with the concept of indexation, some of them would nonetheless prefer not to invest in indexed financial products, while no logical argument for resisting indexation was provide. One of the respondents said *"I want to know how much money I will be getting*". This statement may capture the basic sentiment involved in the evolution of money value through time. Besides, it

[1] Fisher co-founded the company, Rand-Kardex Co. issued in 1925 the first inflation-indexed bonds since 1780. These bonds tied to an index of consumer prices (and not just a single commodity).

may illustrate what seems to be a specific need, the desire money for its own sake. As Bourgeois-Gironde and Guille (2011) point out money illusion is linked to the perception of money and may particularly be related to this desire of money regardless of its purchasing power, which is called money as a *drug* by opposition to money as a tool (Lea and Webley, 2006). These findings echo Fisher's argument in 1928 whereby private individuals do not trust indexation because they are used to think through money as a standard of value and feel intuitively more comfortable with certain cash flows in nominal terms. In other words, real uncertainty may be preferred to nominal uncertainty. Another possible reason for the scarce success of indexed bonds may be related to the difficulties that a less educated population would have with indexed number calculations. As pointed out by Shiller when speaking of speaking of Massachusetts indexed bond in 1780*, "Not only are people troubled by* math anxiety *when doing index calculations, but also people have a difficulty with* intuitive understanding of the indexation concept. *If this is true today, then it is all the more likely to have been true in colonial America"* (Shiller, 2003, p13).

Money illusion and then as consequences acceptation of inflation-indexed bonds can be influenced by capabilities such that numeracy and financial literacy.

As defined by the OECD (2005), *"[f]inancial education is the process by which individuals improve their understanding of financial products and concepts; and through information, instruction and/or objective advice develop the skills and confidence to become more aware of financial risks and opportunities, to make informed choices, to nowhere to go for help, and to take other effective actions to improve their financial well-being and protection."*

Empirical survey and studies about the influence of financial literacy over households' financial choices and outcome are numerous and all agree on the fact that financial knowledge lead to a better management of finance: propensity to have a pension plan, portfolio diversification, etc. Huston (2012), for example, highlights a negative relationship between financial literacy and the cost of financial borrowing whatever is the channel used: credit card borrowing or credit borrowing loans. Households with financial knowledge are more likely to have lower borrowing costs than household with low financial knowledge. In addition, Lusardi & Mitchell (2011) showed that Americans who are financially literate are more likely to prepare a retirement plan. More precisely Arrondel, Debbich and Savignac (2014) in their studies about households' investment (PATER surveys) found that women, young people, the elderly and those with low education have less financial knowledge than others. They also found that financial literacy affects households' portfolio composition. Indeed, the more the households are financially literate the more they hold stocks in their portfolio. However, the

allocation of the portfolio itself (the share invested in stocks and the share invested in other financial products) is still influenced mainly by the expected return and the households' risk aversion. Moreover, Van Rooij, Lusardi and Alessie (2011) show that financial knowledge and numeracy are strongly positively correlated with the participation in the equity market. In another paper, Van Rooij, Lusardi and Alessie (2012), they found positive relationships between financial knowledge, pension plans and household wealth. They show that financial literacy can increase households' wealth via two mechanisms. Indeed financial literacy increases the propensity of households' to invest in equity markets, therefore to benefit from equity premia. Moreover, as already mentioned, they found that financial literacy increases the likelihood of households' to have a retirement plan therefore to have pension income for their old age.

Consequently, financial literacy and numeracy are determinants in households' financial choices and elaboration of pensions plan.

In this study we then analyze the influence of financial literacy and numeracy over money illusion. In order to do so we design and create an experiment as an individual incentive choice task to measure money illusion. This task consists in a series of choices between a pair of simple bonds which returns are influenced by inflation (deflation) rates. The key intuition behind our experiment is the following.

We consider participants who do not choose the right bond (having the best real return) make errors when calculating real values or real rates of return and are then suffering from money illusion. Consequently we made the following hypothesis: the error rate in our experiment is an individual measure of money illusion (H1). This can occur when, faced with a nominal decision making, participants only take into account nominal values or nominal rates of return, or take into account the inflation rate but do so inaccurately.

Then we design our experiment such that we can control the usual effect of different internal framings over money illusion. Consequently, we assumed that: money illusion increases in deflation framing (H1a); increases when financial choices are framed in high value (H1b); increases when choices are more difficult to compute (H1c); finally, money illusion increases when financial choices are not congruent (H1d). We relate our task to a money illusion questionnaire closed to that of Shafir, Diamond and Tversky's (1997) in order to attest the external validity of our task. We make the following hypothesis: participants who have a high score of money illusion in the money illusion questionnaire have high error rates in our task (H1e).

These errors - money illusion- may be due to financial literacy (misunderstanding of the nature of assets or of the impact of inflation over the value of it's the asset's return) or to numeracy (miscalculation). Consequently we assumed that money illusion decreases with financial literacy (H2a) and with numeracy skills (H2b).

Besides, we propose to participants to make financial choices via two other framings to check is there is a framing effect in the task. This intervention consists first to present the nominal return of the bonds (Alpha) rather than theirs nominal values (Beta). This framing is more related to the usual presentation of the bonds. We assume that money illusion will decreases in the nominal rate of return framing (Alpha) (H3a) since real returns are easier to compute and compare than real values. The second framing (Delta) present the real values of the bonds rather than their nominal values which enable to test the influence of nominal vs real framing and the subsequent issue of inflation-indexed bonds. We assume that money illusion increases in the real framing (Delta) since real values seem difficult to understand which is supported in particular by the reluctance to buy inflation-indexed bonds (H3b).

2. METHOD

Procedure and participants

The experiment was conducted in French and run at the LEEP (the Experimental Economics Laboratory of Paris) at the University of Paris 1. Subjects were recruited using an online system. There were 96 participants (44 females and 52 males) aged 24.6 years old on average. 30 participants hold a master degree, 39 a bachelor degree and 27 are graduated from high school. Besides, 14 participants are enrolled in a law degree and 19 in an economics or finance degree. Overall 52 participants follow at least a course in Economics or Finance. The experiment consisted of six sessions. There were 11 to 18 participants in each session. Each individual could only participate in one session. Sessions averaged approximately one hour and twenty minutes in length. The mean gain was 20.5 euros (*sd* = 1.42). The gain was calculated across one randomly drawn financial choice, one risk aversion lottery, success in division's task plus 5 euros participation fee.

Summary of the design

The experiment is divided in 8 steps. Participants have to answer, in the following order, to a first questionnaire which consists only on sociodemographic questions, a first trial of financial choices (Beta certain and uncertain bonds), a second questionnaire mixing financial literacy

and money illusion questionnaires, a second trial of financial choices (Alpha certain bonds), a third questionnaire mixing financial literacy and money illusion questionnaires, a third trial of financial choices (Delta certain and uncertain bonds), the Holt-Laury aversion procedure, a loss aversion measure and finally a division task.

Instructions were read and orally explained, projected on individual computer and printed it out.

Questionnaires

Financial literacy questionnaire

4 questions are asked to the participants. Three of them were already used to study financial literacy (Arrondel and Masson, 2014; Lusardi and Mitchell, 2014; Arrondel, Debbich, & Savignac, 2014). Our first two questions (FLQ1 & FLQ2) enable us to check if people understand interest rates, the third question (FLQ3) measures the understanding of the inflation concept. We add a four question related to our experimental task (FLQ4): "*What will be the real value of an investment of 1000 invested for a year at the rate of 10% for an inflation rate of 5 %?*").

Money illusion questionnaire

We compute an index for money illusion through the answers of participants to twenty questions. Several of them were already used to study money illusion (Shafir, Diamond and Tversky, 1997; Guille and Mercier, 2017). We add a specific problem in relation to indexed bonds (IMQ9).

Numeracy

We create a specific numeracy task in which participants have to compare six pairs of ratios. Each ratio is created over values used in the financial task.

Experimental task

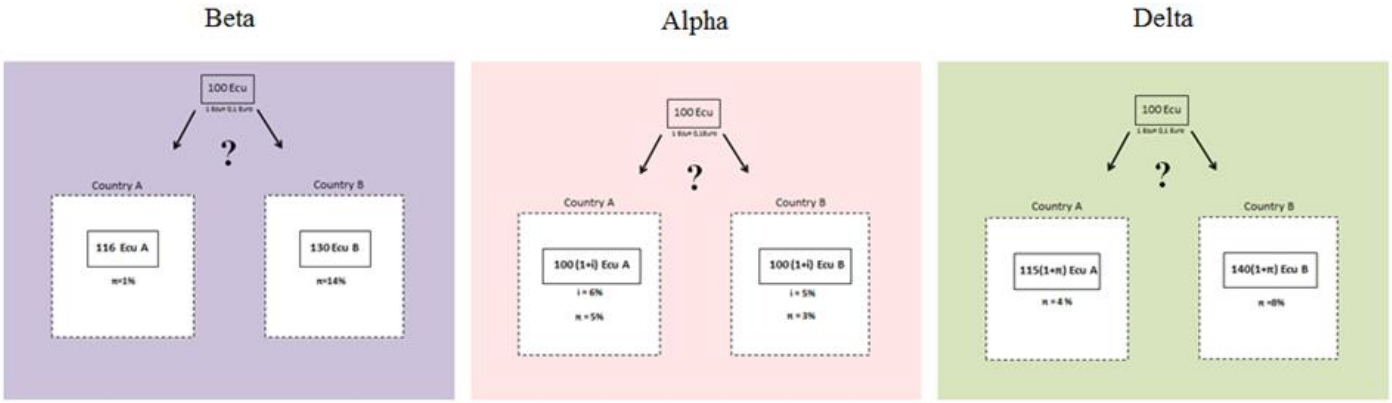
Financial task

Participants have to answer to 68 different financial choices. We introduce an experimental unit of account (the ECU) in order to process to financial choices. The exchange rate of the ECU in euro is always mentioned and depends on the inflation (deflation) rate. For each financial choice participants have to choose to invest between two simple bonds (A or B) of one period which have the same initial value (ECU 100) and differ only by their return which is affected by an inflation (deflation) rate, the return being presented in the form of nominal value, real value or interest rate depending on the framing. As we already mentioned financial

choices are presented in three different framing that we called Beta, Alpha and Delta (see Figure 1 and Appendix 1 for a more detailed description).

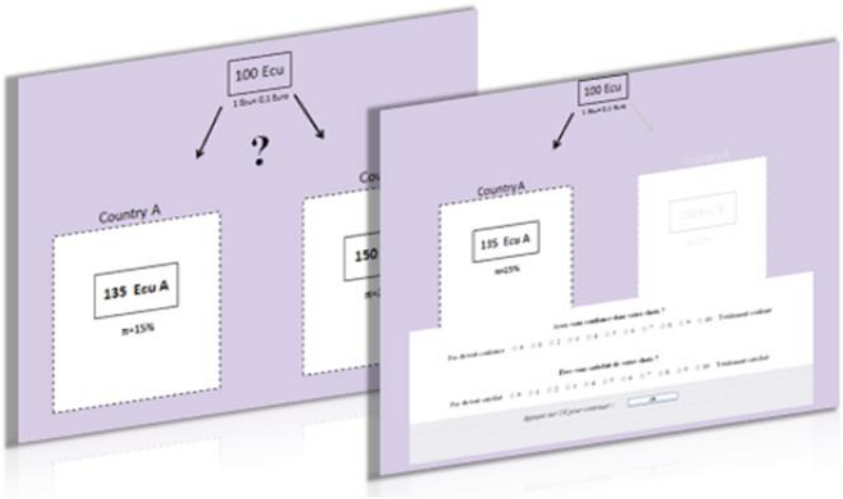
In the Beta framing financial choices are presented in the form of nominal value (*NV*) with the inflation (deflation) rate (π). In the Alpha framing, financial choices are presented according to their nominal rate of return (*NR*) and inflation rate (π) and finally in the Delta framing financial choices are presented in their real value (*RV*) with the inflation rate (π).

Figure 1: The three framing of financial choices



Once participants have chosen the financial bond to invest in they have to answer to a satisfaction question ("*Are you satisfied with your choice?")* and to a confidence question ("*Are you confident in your choice?"*) (See Figure 2). Both questions are evaluated via a 10-point Likert scale.

Figure 2: Illustration of the financial task with an example of financial choice in the Beta framing.



Note: First participants have to select the financial bond in which they want to invest; second, they have to indicate the level of satisfaction and of confidence they get with the bond they have chosen.

First trial 40 certain financial pairs of bonds in Beta framing are presented to the participants and 5 uncertain pairs of Beta bonds.

Plus, we design the Beta pairs of bonds such as:

- 19 pairs of bonds relate to an Inflation-Inflation context (we called this situation the "Inflation" condition), 5 to a Deflation-Deflation context and 6 to a Inflation-Deflation context. (These two last situations constituted what we called the "Deflation" condition)
- 30 pairs of bonds are considered to be non-congruent and 10 to be congruent. We defined congruency such that a pair of bonds (A, B) is congruent if $arg\ max\ \{NV_A, NV_B\} = arg\ max\ \{RV_A, RV_B\}$.
- 24 pairs of bonds are considered to be in low value condition and 16 to be in a high value condition. Financial choices belonged to the low value condition if the experimental income is equal to 100 and the exchange rate between the ECU and the euro is equal to 0.1. On the contrary, financial choices belonged to the high value condition if the experimental income is equal to 1000 and the exchange rate between the ECU and the euro is equal to 0.01.
- 16 pairs of bonds are considered to in high difference condition and 24 in low difference condition. We defined the low difference condition such that the difference between the nominal value of the two bonds is low (1 ECU in the low value condition; 10 ECU in the high value condition); in the high difference condition this difference is high (6 ECU in the low value condition; 60 ECU in the high value condition).

Second trial is composed by 20 pair of bonds in certain Alpha framing. All these 20 financial choices are designed from certain Beta bonds.

Third trial is constituted of 20 certain pairs of bonds in Delta framing. Over these 20 certain pair of bonds 5 are built upon Beta choices.

We have common financial pair of bonds in the three different framing.

Risk aversion

Risk aversion was elicited through a Holt & Laury (2002) procedure. The gains in the sure option (A) were respectively 2 € and 1.6 € while the gains in the risky option (B) were respectively 3.85 € and 0.1 €. Subjects have to make ten choices with the high gain's probability going from 10% to 100 % by step of 10%. All the choices were displayed simultaneously in one table. To avoid multiple switches between the two options, subjects could switch from option A to option B one time at most.

Loss aversion

To elicit loss aversion, subjects were asked to choose between: a lottery ticket (A') which gives 50% chance of winning 50 € and 50% chance of losing 50€, and a sure outcome (B'). There were eleven choices with a sure outcome varying from + 50 € to – 50 € by step of 10 €. All the choices were displayed simultaneously in one table and multiple switches were not allowed. Subjects could switch from option A' to option B' one time at most. The choices were not incentivized.

Measures

Questionnaires

Financial literacy: We create a financial literacy indicator via the computation of the four answers the participants gave to the financial literacy questionnaire.

Money illusion: A money illusion indicator is created according to the 20 answers that participant gave to the money illusion questionnaire.

Numeracy: We compute a score of numeracy according to the six answers participants gave to the numeracy task.

Experimental task

Metacognitive efficiency measure: We define metacognition efficiency as the difference between the mean confidence in correct choices of bonds and the mean confidence in incorrect choices of bonds. The higher the difference, the more able a subject is to detect his errors.

Response time: For each choice the time of response (seconds) of each participant is recorded.

Loss aversion: We measure loss aversion by the number of times the lottery ticket was chosen.

Risk aversion: We measure risk aversion by the number of times the sure option was chosen.

Mean error rate in the financial task: Each error in the financial choices task is considered as the expression of money illusion. Consequently for each participant we compute an individual score of money illusion which is equivalent to his mean error rate in the task.

3. RESULTS

Descriptive results

Questionnaires

Financial literacy: 92,7% of our participants give the right answer to FLQ1; 61.5% to FLQ2 (48 % for Arrondel, Debbich, & Savignac, 2014); 80,2% to FLQ3 (61% for Arrondel,

Debbich, & Savignac, 2014) and 52, 1% to FLQ4. Overall the mean score of right answers is: M= 2.86, *sd*= 1.04.

Money illusion questionnaire: Overall the mean score through the money illusion questionnaire is M=10.96 (*sd*=3.88).

Numeracy: The mean score of correct answer for the six divisions is equal to 4.30 (*sd*= 1.6).

Experimental task

Loss aversion: The mean score is equal to M=4.78 (*sd* =2.42).

Risk aversion: the mean score is equal to M=6.17 (*sd*= 2.07).

Metacognitive efficiency measure: The mean score is equal to M=0.54 (*sd*=.80).

Mean error rate in the financial task: Overall (Beta certain), participants have a mean error rate equals to .31 (*sd*=.20). There are significant differences between male and female and between participants who declared to follow economics or finance lectures and others (Table 1).

Table 1: Mean errors and T-test over the mean error in the task according to socio-demographics characteristics.

VARIABLES	EcoFi	Others	Male	Female
Mean error rate	.27	.36	.27	.36
	(.02)	*(.03)*	*(.03)*	*(.03)*
	t(94)=2.16***		t(94)=-2.54***	
Numeracy	4.63	3.91	4.68	3.98
	(.20)	*(.25)*	*(.20)*	*(.23)*
	t(94)=-2.28***		t(94)=2.2***	
Financial literacy	3.15	2.52	3.27	2.5
	(.13)	*(.16)*	*(.13)*	*(.15)*
	t(94)=-3.08***		t(94)=3.76***	
Money illusion questionnaire	9.46	12.73	9.57	12.13
	(.56)	*(.42)*	*(.63)*	*(.44)*
	t(94)=4.51***		t(94)=-3.40***	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Main results

Individual money illusion or mean error rate according to choice characteristics (Beta certain) (H1).

A logistic regression analysis (Table 2, column 1) was conducted to explain the mean error rate in the task according to the choices characteristics. Inflation and congruent financial choices cause a lower mean error rate (e.g. on average participants make less errors when

financial choices are framed in inflation rather in deflation contexts, ceteris paribus). On the contrary financial choices in high value, high difficulty situations lead participants to have a higher mean error rate.

Then two OLS regressions (Table 2, column 2 and 3) were conducted over confidence and response time. We found that participants are more confident in their answers in inflation situations (rather in deflation) and less confident in high value and high difficulty situations.

Table 2: Characteristics of the choice over the mean error rate, confidence and response time in the task

VARIABLES	(1) Odds ratio mean_error	(2) confidence	(3) Response time
Method	*logit*	*OLS*	*OLS*
Observations	*3,840*	*3,840*	*3,840*
Congruent	0.633***	-0.121	1.611**
	(0.0623)	(0.0906)	(0.717)
high_value	1.345***	-0.173**	2.639***
	(0.100)	(0.0671)	(0.530)
high_difficulty	1.287***	-0.340***	1.013*
	(0.0966)	(0.0667)	(0.527)
Inflation	0.531***	0.316***	0.751
	(0.0443)	(0.0765)	(0.605)
Constant	0.497***	7.321***	10.12***
	(0.0437)	(0.0806)	(0.638)

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: R-squared= 0.018 for Confidence and R-squared= 0.010 for response time

External validity of the task *(H1e):* Measures of money illusion in the task (mean error rate) and in the questionnaire are significantly and positively correlated, r=.37, p<0.01.

Influence of individual characteristics over individual measure of money illusion (Beta certain) (H2).

Three regressions were conducted in order to study the influence of individual characteristics (numeracy, financial literacy, loss aversion and risk aversion) over the performance in the task, metacognition and degree of money illusion in the questionnaire.

We found that there is a decreasing relation between mean error rate in the task and success in the financial literacy questionnaire (Table 3, column, 1), and an increasing one with metacognition (Table 3, column 2). However, if we control for the error rate there is no longer any significant relationship between financial literacy and metacognition.

Moreover, there is a decreasing relationship between mean error rate in the money illusion questionnaire and success in the financial literacy questionnaire *(H2a)* and also with the numeracy questionnaire *(H2b).*

Table 3: Influence of individuals characteristics over mean error rate in the task, metacognition, and score of money illusion in the questionnaire

VARIABLES	(1) mean_error	(2) metacognition	(3) MI-Question.
Method	*OLS*	*OLS*	*OLS*
Observations	*96*	*96*	*96*
R-squared	*0.217*	*0.089*	*0.302*
Numeracy	-0.00729	-0.0153	-0.574**
	(0.0128)	(0.0544)	(0.231)
Fin.lit.	-0.0875***	0.226***	-1.700***
	(0.0187)	(0.0794)	(0.337)
loss_aver	0.00422	0.0213	0.127
	(0.00825)	(0.0351)	(0.149)
risk_aver	0.0114	-0.0405	0.216
	(0.00938)	(0.0399)	(0.169)
Constant	0.504***	0.110	16.35***
	(0.0838)	(0.357)	(1.515)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Framing (H3)

Alpha (H3a)

Error rate in Alpha (M=.26, sd=16) is positively correlated with the mean error rate in Beta, r=.68, p<0.01. The difference between the two mean of errors is not significant. We found a decreasing relation between mean error rate in Alpha and loss aversion and an increasing relation between mean error rate in Alpha and mean error rate in Beta.

Table 4: Regression of individual characteristics over the mean error rate in Alpha.

VARIABLES	mean_error_Alpha
Method	*OLS*
Observations	*96*
R-squared	*0.517*
mean_error_Beta	0.471***
	(0.0672)
numeracy	-0.00290
	(0.00865)
Fin.Lit.	-0.0205
	(0.0148)
MI-Question.	0.00396
	(0.00384)
loss_aver	-0.01000*
	(0.00542)
risk_aver	0.00635
	(0.00620)

Constant	0.166*
	(0.0863)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In order to be more precise we look at the influence of the individual characteristics over the rates success or the nonsuccess in Alpha. Two logistic regressions are computed.

We found an increasing relation between unsuccess in Alpha and loss aversion. There are increasing relations between success in Alpha and success in numeracy, financial literacy or money illusion questionnaires. However success in Alpha is decreasing with loss aversion.

Table 5: Influence of individual characteristics over successfulness in Alpha

VARIABLES	(1) Odds ratio unsuccess.	(2) Odds ratio success.
Method	*logit*	*logit*
Observations	*96*	*96*
numeracy	1.149	0.668**
	(0.205)	(0.128)
Fin.Lit.	1.569	0.456**
	(0.449)	(0.152)
MI-Question.	0.999	0.849*
	(0.0710)	(0.0782)
loss_aver	0.792*	1.233*
	(0.0991)	(0.138)
risk_aver	1.088	1.107
	(0.133)	(0.157)
Constant	0.0907	12.94
	(0.150)	(24.95)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Delta (H3b)

Error rate in Delta (*M*=.31, *sd*=.35) is positively correlated to the mean error rate in Beta, r=.36, p<0.01. The difference between the two mean of errors is not significant.

We found an increasing relation between mean error in Delta and success in the money illusion questionnaire.

Table 6: Regression of individual characteristics over the mean error rate in Delta

VARIABLES	mean_error_Delta
Method	*OLS*
Observations	*96*
R-squared	*0.223*
mean_error_Beta	0.407***
	(0.122)
numeracy	0.0244
	(0.0230)
Fin.Lit.	0.0595

	(0.0381)
MI-Question.	0.0298***
	(0.0100)
loss_aver	-0.0135
	(0.0143)
risk_aver	0.0128
	(0.0165)
Constant	-0.424*
	(0.224)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In order to be more precise we look at the influence of the individual characteristics over the success or the nonsuccess in Delta. Two logistics regressions are computed.

We found two decreasing relations between unsuccess in Delta and success in financial literacy or money illusion questionnaires. There is an increasing relation between success in Delta and numeracy.

Table 7: Influence of individual characteristics over successfulness in Delta

VARIABLES	(1) Odds ratio unsuccess.	(2) Odds ratio sucess.
Method	*logit*	*logit*
Observations	*96*	*96*
numeracy	1.272	0.711*
	(0.292)	(0.132)
Fin.Lit	1.898*	0.838
	(0.665)	(0.260)
MI-Question.	1.197*	0.985
	(0.116)	(0.0887)
loss_aver	0.894	1.137
	(0.133)	(0.129)
risk_aver	1.085	1.106
	(0.169)	(0.161)
Constant	0.00123***	0.475
	(0.00279)	(0.903)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

DISCUSSION

Our findings mainly support our hypotheses.

Firstly, participants make frequent errors in the task. On average, the rate of errors equals 31% in Beta framing which means many participants do not take correctly into account nominal values when choosing between two certain bonds. Moreover this rate of errors depends on choice characteristics. Indeed, participants make more errors in deflation than in inflation contexts (H1a). Besides, participants make more errors when choices are framed in

high value (H1b), when they are more difficult to compute (H1c) and when they are not congruent (H1d). Finally, the participants' mean error rate (Beta framing) is positively correlated with their individual score in the money illusion questionnaire. These results support our first hypothesis (H1). On one hand, our results are consistent with previous findings in other type of studies, regarding the prevalence of money illusion and the asymmetry between inflation and deflation contexts. In money illusion surveys, participants' answers are more biased by money illusion when comparing inflation and deflation scenarios and even when participants are able to select the most profitable scenario in real terms they are not satisfied with it, if deflationary (see Shafir, Diamond and Tversky (1997); Mees and Franses (2014); Guille and Mercier (2017)). Moreover, Fehr and Tyran (2001) provide behavioral evidence that money illusion has asymmetric effects on equilibrium adjustment depending on whether the shock is positive or negative. On the other hand, we show that money illusion is also dependent on two characteristics of financial choices: value and complexity. High nominal value and difficulty to compute real bonds values tend to increase money illusion bias.

Our findings also partially support our second hypothesis (H2). Money illusion is not very dependent on individual characteristics (Beta certain framing). More precisely, we observed only a decreasing and very significant relation between mean error rate in the task and success in the financial literacy questionnaire (H2a) while the relation with numeracy skills is not significant (H2b) as well as those with loss aversion and risk aversion. These results suggest a close relationship between financial literacy and money illusion. More financial literate participants seem less sensitive to money illusion which raises the issue of a possible debiasing of money illusion by specific programs of financial education. By contrast, numeracy skills do not seem to help participants in the task. This is surprising since to compare the two bonds calculus are required and these calculus are closed to the ones in the numeracy questionnaire. This result may suggest that money illusion bias cannot be confined to simple mistakes of real values computation from nominal values.

Our results barely support our framing hypothesis (H3). Indeed the difference between the rates of error in the Alpha and Beta framings is not significant and there is no difference between Delta and Beta rates of error. Hence participants do not benefit or be disadvantaged by both framing interventions contrarily to what we expected (H3a and H3b). Consequently, participants are as well affected by money illusion in all the three formats. There is then no framing effect in our task. Nevertheless, our results support the hypothesis of a decreasing relation between not only financial literacy, but also numeracy skill, and money illusion.

Indeed, success in Alpha framing is highly explained by success in financial literacy and numeracy questionnaires while in the Delta framing, numeracy skills explain the success and financial literacy decreases the rate of unsuccess. Consequently financial literacy and numeracy seem to play a major role in both framings to reduce money illusion bias.

As previously pointed out by the literature these skills could allow individuals to make better financial choices and get financial outcomes. Indeed, governments or international organizations such as the OECD have implemented official programs of financial literacy in order to increase financial capabilities of populations. However, empirical studies show that these types of programs appear to be ineffective to improve financial decisions (Fernandez, Lynch and Netemeyer, 2014, Benartzi and Thaler, 2004). In the light of our results, these programs could nevertheless have a positive impact on money illusion bias. This hypothesis could be tested in further studies since money illusion matters in many financial decisions, particularly long term ones (saving, pension, loans or real estate decisions).

CONCLUSION

In this paper we propose a simple, incentivized and fine grain individual measure of money illusion bias. This experimental measure is correlated with usual questionnaire measure of money illusion.

In average, according to this measure, thirty percent of the participants are affected by money illusion and this prevalence is relatively unaffected by the framing of the choices participants are faced to. However, participants are highly sensitive to the internal contexts of the financial choices they are faced to. Particularly, they are more affected by money illusion in deflation than in inflation situations, which is consistent with previous findings. Moreover they are affected by the internal design of the choices. Money illusion increases with the value of the bonds and with the difficulty to compare bonds returns.

Thanks to this task, we also have learned that two cognitive abilities are related to money illusion sensitivity: Numeracy and financial literacy. There is indeed large evidence in our findings that financial literacy and numeracy reduce money illusion bias.

These results emphasize the issue of financial education such as the financial literacy program of the OECD since the consequences of money illusion cannot be ignored, particularly in long term financial choices (pensions, loans, savings etc.). These programs could include specific parts on the understanding of the difference between nominal and real values for example. More generally this should lead to further studies on the possibilities and on the tools that could be used to debiase people affected by money illusion.

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APPENDICES

Appendix 1: Questionnaires

Monetary Illusion Questionnaire

Instructions
please answer the questions below, after carefully reading each question. Indicate what you really think. For each question please tick the chosen answer: one answer per question.

Question 1
Suppose you do not have any savings or debt, and you had anticipated the purchase of an armchair at the price of 400 euros with your monthly salary, but that in the meantime the prices of goods and services have increased on average 25%, all other things being equal. Your salary has also increased by 25%. As for the price of the chair, it went from 400 to 500 euros.
[IMQ1_1] Do you think you are more or less inclined to buy it than before?
Much more □ A little more □ As much □ A little less □ Much less

You had also anticipated the sale of a table at the price of 400 euros; You can now sell it at the price of 500 euros.
[IMQ1_2] Do you think you are more or less inclined to sell it than before?
Much more □ A little more □ As much □ A little less □ Much less

Question 2
Suppose you do not have any savings or debt, and you had anticipated the purchase of an armchair at the price of 400 euros with your monthly salary, but meanwhile the average prices of goods and services have decreased by 25 %, all things equal otherwise. Your salary has also decreased by 25%. As for the price of the chair, it went from 400 to 300 euros.
[IMQ2_1] Do you think you are more or less inclined to buy it than before?
Much more □ A little more □ As much □ A little less □ Much less

You had also anticipated the sale of a table at the price of 400 euros; You can now sell it at the price of 300 euros.
[IMQ2_2] Do you think you are more or less inclined to sell it than before?
Much more □ A little more □ As much □ A little less □ Much less

Question 3
You lived in a house that you bought 200,000 euros a year ago but you decide this year to sell it to immediately buy another house in the same area with the full price of the sale. Consider the following three alternative scenarios:

Scenario A: Prices for all goods and services, as well as homes and apartments, decreased by 25%. You can sell your house at a price of 154,000 euros (23% less than what you paid).

Scenario B: There was no inflation or deflation, all prices remained stable, and you can sell your house at a price of 198,000 euros (1% less than what you paid).

Scenario C: Prices of all goods and services, as well as houses and apartments, increased by 25%. You can sell your house at a price of 246,000 euros (23% more than what you paid).

[IMQ3_1] Which scenario do you think is the most profitable for the double transaction (selling the house and then buying another one at the market price)?
Scenario A □ Scenario B □ Scenario C □I do not know

[IMQ3_2] Which scenario do you think can be achieved by doing the double transaction (selling the house and then buying another at the market price) the least profitable?
Scenario A □ Scenario B □ Scenario C □I do not know

[IMQ3_3] Which scenario would bring you the greatest satisfaction?
Scenario A □ Scenario B □ Scenario C □I do not know

[IMQ3_4] Which scenario would bring you the least satisfaction?
Scenario A □ Scenario B □ Scenario C □I do not know

Question 4
Suppose you have neither savings nor debt and that you spend your monthly salary of 1600 euros every month, but not more, that is to say that you do not endure. Two scenarios are possible.

Scenario A: Prices remain the same and you get a 2% salary increase. Your salary goes from 1600 euros to 1632 euros.

Scenario B: There is an inflation of 4% and you get a salary increase of 5%. Your salary goes from 1600 euros to 1680 euros.

[IMQ4] Which scenario do you think is best?
Scenario A Scenario B □ □ I do not know pas□

Question 5
Suppose you have neither savings nor debt and that you spend your monthly salary of 1600 euros every month, but not more, that is to say that you do not endure. Two scenarios are possible.

Scenario A: There is an inflation of 1% and you get a salary increase of 3%. Your salary goes from 1600 euros to 1648 euros.

Scenario B: There is an inflation of 4% and you get a salary increase of 5%. Your salary goes from 1600 euros to 1680 euros.

[IMQ5] Which scenario do you prefer:
Scenario A □ Scenario B □ Do not know

Question 6
The economy experienced an inflation rate of 5% this year. The firm that employs Tom saw its profits increase by 5% compared to last year, and decides to increase the salary of all its employees by 5%. Tom's salary thus increases from 1120 euros to 1176 euros.

[IMQ6_1] Do you think Tom considers his financial situation:
More favorable □ Unchanged □ Less favorable □ Do not know

[IMQ6_2] In your opinion the situation of Tom and the other employees is:
Just □ Unjust □ It depends □ I do not know

Question 7
All of the economy's prices decreased this year by 5%. The firm that employs Tom saw its profits decrease by 5% compared to last year, and decides to decrease the salary of all its employees by 5%. Tom's salary thus decreases from 1120 euros to 1064 euros.

[IMQ7_1] Do you think Tom considers his financial situation:
More favorable □ Unchanged □ Less favorable □ Do not know

[IMQ7_2] In your opinion the situation of Tom and the other employees is:
Just □ Unjust □ It depends □ I do not know

Question 8
Julie buys a one-year bond that has a nominal value of 1000 euros and brings in an annual interest rate of 5% knowing that it anticipates an inflation rate of 2%.
After a year, Julie receives 1050 euros: the nominal of 1000 euros and 50 euros of interest.

Scenario A: after one year, the economy experienced an inflation rate of 4%.
[IMQ8_1] Compared to what she had anticipated, do you think Julie's placement told her:
Less □ As much □ More □ Do not know

Scenario B: after one year, there was no inflation (prices remained stable).
[IMQ8_2] Compared to what she had anticipated, do you think Julie's placement told her:
Less □ As much □ More □ Do not know

[IMQ8_3] Which scenario do you think is better for Julie?
Scenario A □ Scenario B □ None of the two □ I do not know

Question 9
Julie buys a one-year inflation-indexed bond with a nominal value of 1,000 euros and brings in an annual interest rate of 4 percent, knowing that it anticipates an inflation rate of 1 percent.
After a year, Julie receives 1000euros upgraded from inflation plus interest at the rate of 4% on this new nominal
Scenario A: After a year, the economy experienced an inflation rate of 2% and Julie received 1060.80euros: the new nominal of 1020euros and 40.80euros of interest.
[IMQ9_1] Compared to what she had anticipated, do you think Julie's placement told her:
Less □ As much □ More □ Do not know

Scenario B: after one year, there was no inflation (prices remained stable) and Julie receives 1040euros: the nominal of 1000euros and 40euros of interest.
[IMQ9_2] Compared to what she had anticipated, do you think Julie's placement told her:
Less □ As much □ More □ Do not know

[IMQ9_3] Which scenario do you think is better for Julie?
Scenario A □ Scenario B □ None of the two □ I do not know

Financial literacy questionnaire
[FLQ1] Suppose you deposited € 1000 in a savings account with a return of 2% per year. At the end of a year, how much will you have on your savings account if you have not reached your account?
Less than 1020 euros
Exactly 1020 euros
More than 1020 euros
Do not know

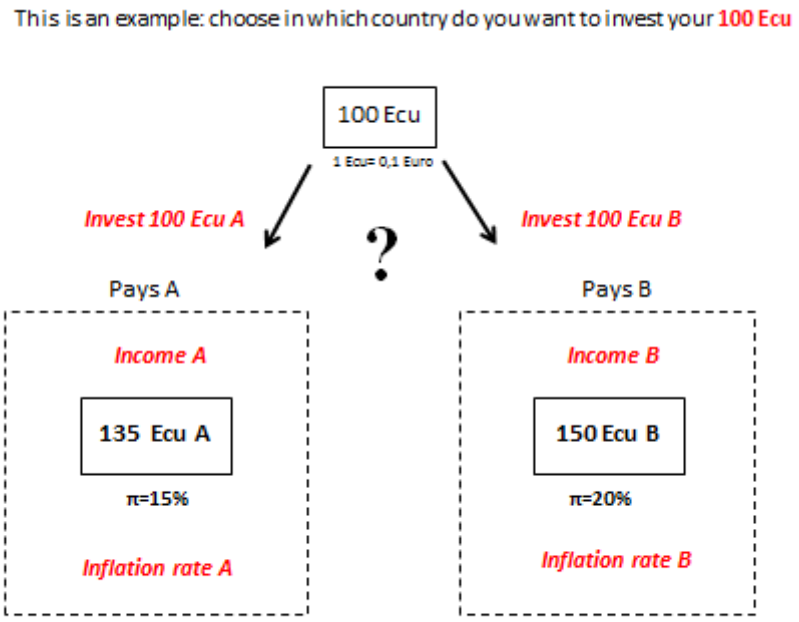
[FLQ2]. After 5 years, how much will you hold on your savings account if you have not touched your account?
Less than 1100 euros
Exactly 1100 euros
More than 1100 euros
Do not know

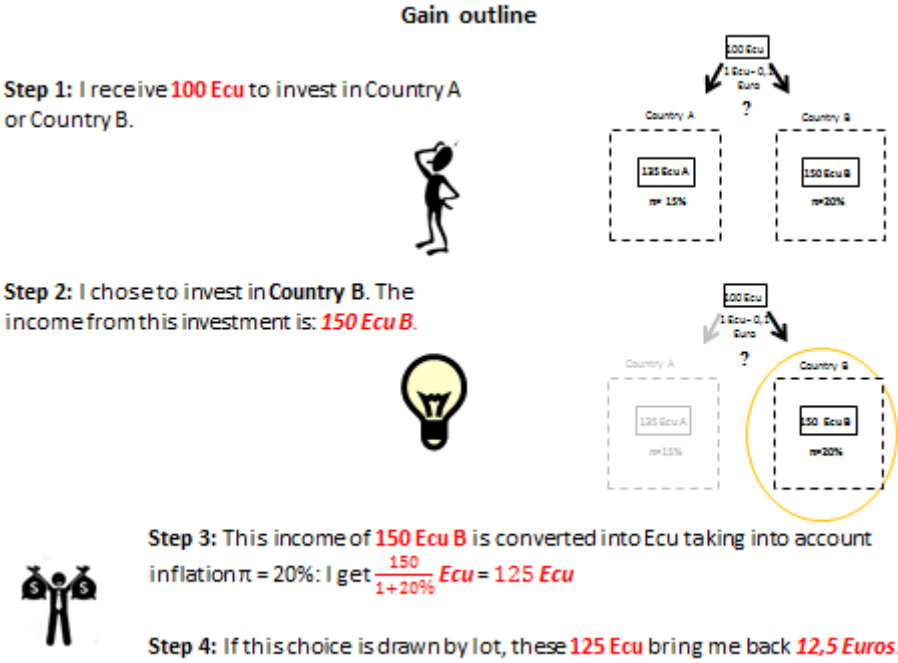
[FLQ3].. Imagine that the interest rate on which your savings are placed in an account is 1% and inflation is 2% per year. According to you, after a year, with the money on this account, you will be able to buy?
More than today
As much as today
Less than today
I do not know
Do not answer
Answer: Less than today

[FLQ4]. What will be the real value of an investment of 1000 invested for a year at the rate of 10% for an inflation rate of 5%?

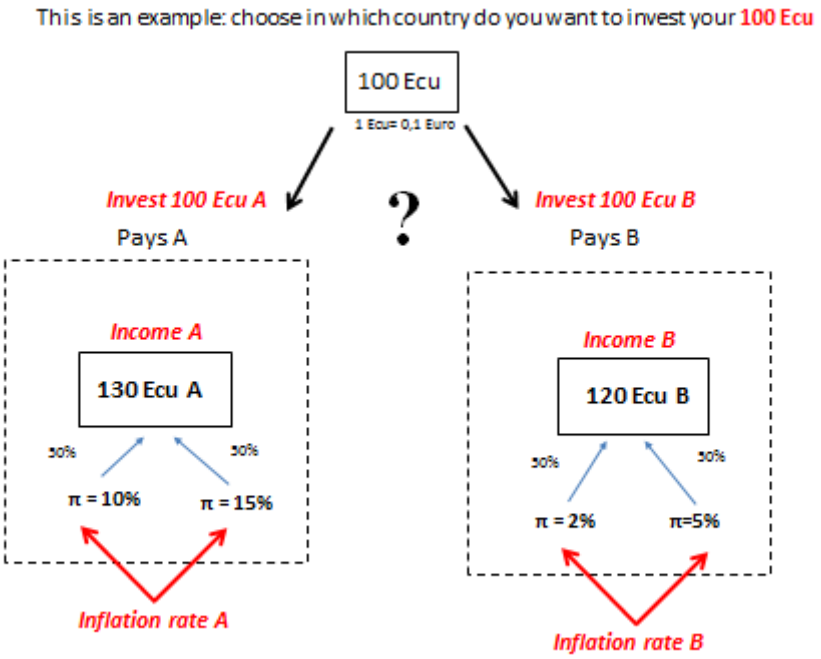
Appendix 2: Experimental Material

Beta certain financial choices





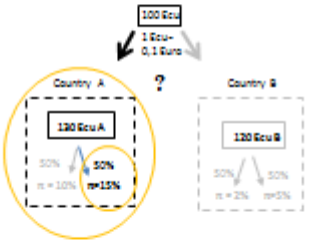
Beta uncertain financial choices



Gain outline

Step 1: I receive 100 Ecu to invest in Country A or Country B.

Step 2: I chose to invest in **Country A**. The income from this investment is: ***130 Ecu A.***

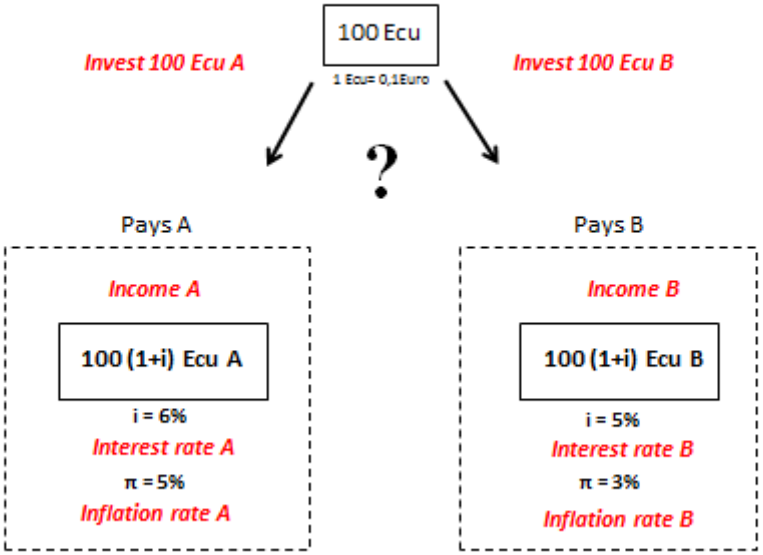


Step 3: This income of 130 Ecu A is converted into ecu taking into account inflation π=15%: I get $\frac{130}{1+15\%}$ ***Ecu = 113 Ecu***

Step 4: If this choice is drawn by lot, these 113 Ecu bring me back ***11,3 Euros***

Alpha certain financial choices

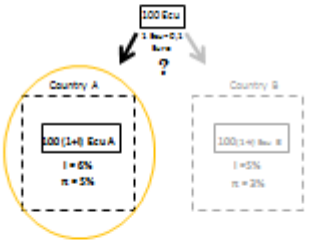
This is an example: choose in which country do you want to invest your 100 Ecu



Gain outline

Step 1: I receive 100 Ecu to invest in Country A or Country B.

Step 2: I chose to invest in **Country A.** The income from this investment is:
$100(1 + 6\%)Ecu\ A = 106\ Ecu\ A$

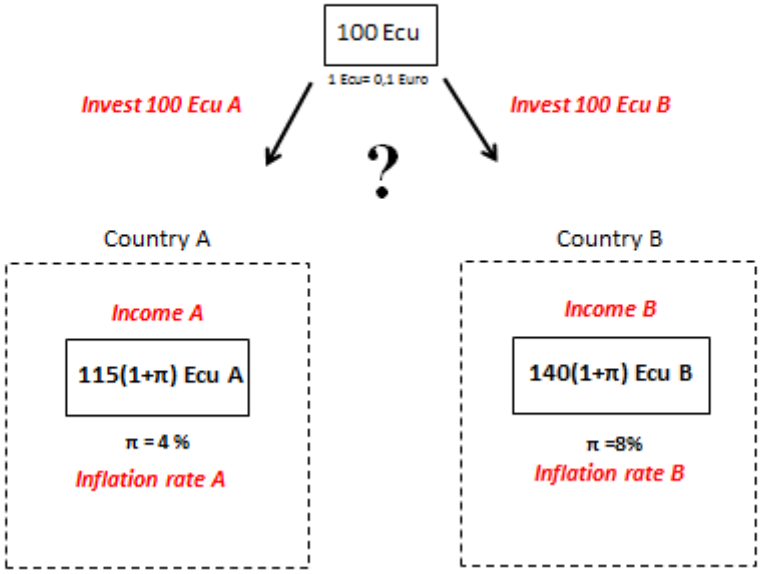


Step 3 This income of 106 Ecu A is converted into Ecu taking into account inflation π=5%: I get $100(\frac{1+6\%}{1+5\%})Ecu = 101\ Ecu$

Step 4 If this choice is drawn by lot, these 101 Ecu bring me back *10,1 Euros*.

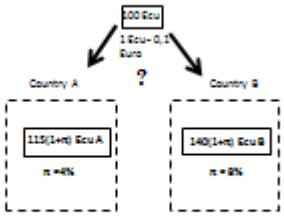
Delta certain financial choices

This is an example: choose in which country do you want to invest your 100 Ecu



Gain outline

Step 1: I receive 100 Ecu to invest in Country A or Country B.

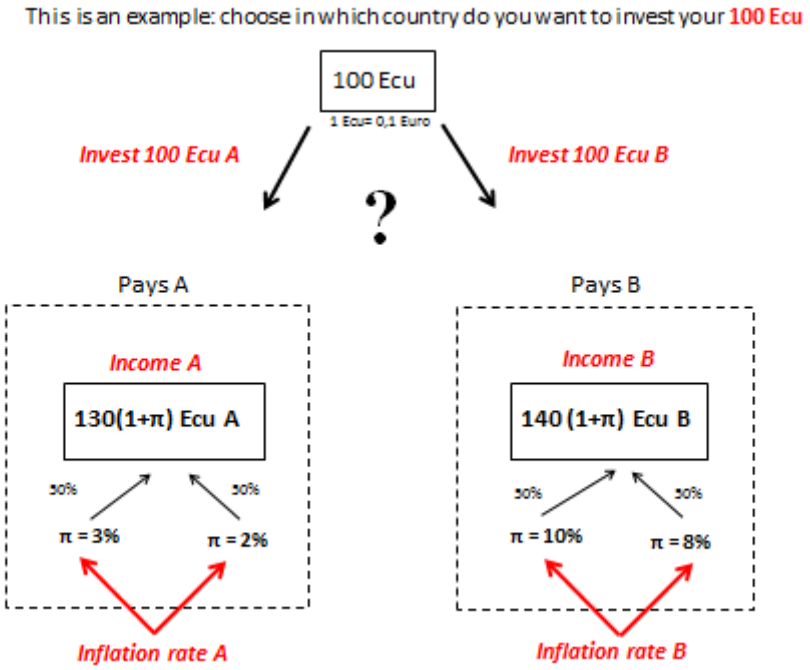


Step 2: I **chose** to invest in **Country A**. The income from this investment is:
115 (1 + 4%)*Ecu A = 119 Ecu A* .

Step 3: This income of 119 Ecu A is converted into Ecu, I get $\frac{119}{1+4\%}$ Ecu = 115 Ecu.

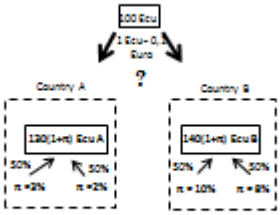
Step 4: If this choice is drawn by lot, these 115 Ecu bring me back *11,5 Euros.*

Delta uncertain financial choices

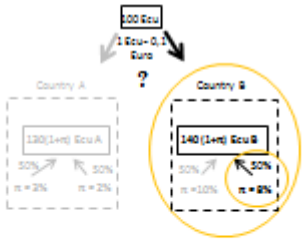


Gain outline

Step 1: I receive **100 Ecu** to invest in Country A or Country B.



Etape 2: I **chose** to invest in **Country B**. The income from this investment is:
$140(1 + 8\%)Ecu\ B = 151\ Ecu\ B.$



Step 3: This income of 151 Ecu B is converted into Ecu, I get $\frac{151}{1+8\%}\ Ecu =$ 140 Ecu.

Step 4: If this choice is drawn by lot, these 140 Ecu bring me back *14 Euros*.